Kenia, as their moraines were found 5000 feet below their present level; this would have a great influence in the distribution of the Alpine flora in equatorial Africa. In spite of the numerous detailed studies of Kilima Njaro, no such evidence had been recorded from that mountain. The fish faunas are remarkably mixed, and show, as has long been surmised, that the distribution of the African rivers was once very different from the present. The geological results of the expedition suggest that at one time the Nile did not flow from the Nyanza, but rose in the mountains to the north; and the drainage of the lakes flowed away to the east and then to the north, past the site of Lake Rudolf to the Red Sea. Thus it was pointed out that the exploration of this part of Africa is of value not merely as supplying topographical information, but from its bearing on some important problems of geographical evolution.

THE GEOLOGY OF AUSTRALIA.[1]

IN the distant future the antiquity that this country can ever possess is the history of the occupation by its present holders; its aboriginal people have not furnished any evidence of a past history, insomuch, had it happened that they had become extinct a quarter of a century before their discovery, the only traces of prior occupation would have been in the form of stone knives and hatchets and flint spearheads. Interwoven with the history of the progress of discovery and occupation is that of the successive additions to our knowledge of its physical structure and its natural history. The records of botanical science and of geographical exploration have been brought up to a recent date; but the annals of the history of geological progress have not yet been consecutively placed on record. In the selection of a subject for my address I had experienced great difficulty in discriminating between personal interest and representative duty, and in choosing a "century of geological progress" for my theme I have sacrificed the former.

The labour involved in the preparation of this address has been very heavy, as I have read a hundred volumes to produce a very modest account; thus what I have done looks small when I recall the continuousness of the effort that accomplished it. The history of the progress of geology in Australia is intimately associated with that of its geographical discovery and of its advancement in scientific culture; it will constitute a chapter in the early history of modern Australia, and I venture to give some connected view of it, which, however bad it may be, is better than to have no view at all; moreover, there are associated with the subject personal histories which should be recorded whilst the knowledge of them is still within our memory. And although it is my special object to depict actual culminating results without any extended notice of the facts and events which may have led up to them, yet to a certain extent a knowledge of such facts and events is essential to their proper appreciation, and may be productive of increased interest.

Just prior to the close of the last century, the controversy between the Wernerian and Huttonian schools, or between Vulcanists and Neptunists, relating to the origin of the crust of the earth, was at its height. The Huttonian theory, which prevailed, recognises that the strata of the present land surfaces were formed out of the waste of pre-existing continents, and that the same forces are still active. The characteristic feature of Hutton's theory is the exclusion of all causes not recognised to belong to the present order of nature. With the opening of the present century a new school arose, which laid the foundation of modern geology. Three men were largely concerned in this achievement—Cuvier, Lamarck, and William Smith; the two former in France had all the powers which great talent, education, and station could give, whilst the last was an English land surveyor without culture or influence. George Cuvier laid the foundation of comparative osteology, recent and fossil; Lamarck that of invertebrate palæontology; whilst Smith established the fundamental principles of stratigraphical palæontology, viz. the superposition of stratified rocks and the succession of life in time.

The earliest geological observations relating to Australia antedate by only a few years the beginning of this century, so that the history of our progress in geology is concurrent with that of modern geology, and it affords grand illustrations of the methods of application of the laws as they were successively evolved in the European schools, to an area so distantly removed from that which gave them birth. Thus our history begins at a most fortuitous period. No prejudices or scholastic disputations have retarded our progress, for those who have aided in the work were disciples in the modern school of geology. And though, on a retrospective glance, we may hesitate to attach any high value to the labours of pioneer geologists, yet we should not forget that our horizon is so much vaster than theirs was, and to the extension of it they had lent their aid. And though it may be true that if the geological progress of the first half of this century were quite ignored, we would not probably suffer any great loss, as I believe that nearly all the areas explored at the earliest period have been re-examined in later times by men more carefully trained than was previously possible, nevertheless the gradual accumulation of data supplies us with a history, and makes us better acquainted with the causes that at certain times made that progress slow, or even retarded it. For the first three or four decades of this century our geological knowledge had been almost entirely the outcome of maritime surveys, whilst in later years it has been largely supplemented by inland exploration; thus, for a half-century or so the geological progress is part of the history of topographical discovery, which explains why our earlier geological information is inseparable from the achievements of such renowned geographers as Flinders, Baudin, King, Sturt, Mitchell, Stokes, Wilkes, Leichardt, Gregory, &c. The subsequent history of our geological progress commences with the establishment of systematic geological surveys in New South Wales and Victoria, which afterwards led to their extension to the other provincial areas. Almost simultaneously, universities were founded at Melbourne and Sydney; thus whilst the surveys dealt with geology more in its industrial applications, the universities upheld its value on purely scientific grounds. By these agencies a large interest was awakened in the science, and many in whom zeal had been latent were added to the ranks of geological investigators. Much of the knowledge gained in these various ways is expressed on the geological map of Australia, published by the Victorian Government in 1887. The several steps by which this map has been built up, I will endeavour to make known to you, and though my geological reminiscences do not extend far back, yet they embrace some of the most important discoveries made on this continent; at the same time I would wish to avoid the mistake of claiming too large an authority on account of my years.

Though the discovery of Australia may date back to the middle of the sixteenth century, yet it continued a *terra incognita*, at least from a scientific point of view, until Cook—the Columbus of the south—began in 1770 the present phase of scientific expeditions; and though geology reaped no gain, yet in botany was laid the foundation of a knowledge of that marvellous and peculiar flora of Australia through the labours of Banks and Solander, the companions of Cook.

Vancouver, who discovered King George Sound in 1791, describes the summit of Bald Head to be covered with a coral structure, amongst which are many sea-shells, and argued a modern date of elevation. However faulty the interpretation of the nature of the data may be, yet the deduction is sound, and that may be claimed as the first recorded geological observation for Australia, made 102½ years ago.

Coal was discovered in New South Wales in 1797, first to the south of Sydney, and in the same year on the banks of the River Hunter, at what is now Newcastle.

Flinders and Bass, jointly and separately, between the years 1797 and 1798, had explored the coast-line southward from Sydney, reaching as far west as Western Port, and embracing the circumnavigation of Tasmania. The more prominent rock phenomena were described. In 1801 Flinders was commissioned to complete the examination and survey of New Holland. The coast-line of Australia was traced with care as far as the tropics; Flinders paid much attention to physiographic features, whilst Brown collected rock specimens. The rock specimens collected on this survey were reported on by Dr. Filton in 1825, but beyond their mere enumeration and their agreement with those of the same denomination from other parts of the world, no attempt was made to chronologically arrange them; others collected by Brown, during his sojourn in New South Wales, were reported on by Dean Buckland in 1821, hereafter referred to.

Contemporaneously with the marine survey by Flinders was that by the French under Baudin. The scientific equipment was unrivalled in the annals of Australian exploration. To Depuch and Bailly were entrusted the mineralogical and geological researches. The former left the ship at Sydney to return to Europe, but he died at Mauritius, and his manuscripts, which he had taken with him, and were to serve for a geological history of New Holland, were irrecoverably lost. Peron was the senior zoologist, and the author of the narrative of the expedition. Peron's account of the physiography and geology of the places visited is not only graphic but rich in details; he closely investigated the nature and origin of the Æolian calciferous sandstones, and fully recognised their relationship to the blown-sand of the dunes. The entombed calcified shapes of branches and stems of trees were correctly recognised, though Vancouver and Flinders had erroneously considered them as coral reefs. He rightly referred the fundamental rocks of Kangaroo and King Islands to different kinds of primitive schists, and the superimposed fossiliferous limestone at the former place was correctly observed, though not attributed to any particular epoch. The occurrence of corals and marine shells of recent apearance at considerable elevations on the coast was justly regarded by him as demonstrating the "former abode of the sea" above the land, and very naturally suggested an inquiry as to the nature of the evolutions to which this change of situation is to be ascribed. Few geologists have been more in advance of the age in which they lived, or have suffered so long an undeserved oblivion, as Peron. After the termination of the survey by Flinders, through the loss of his ship, and subsequent detention by the French, in which France was the first to debase, as she was the first to promulgate, that principal axiom of international law, "Causa scientiarum, causa populorum" (the cause of science is the cause of the people), twelve years elapsed before England's attention was diverted from the battle-field to geographical discoveries in Australia by the appointment of Captain King to complete the coast surveys left unfinished by Flinders, which occupied him from 1818 to 1822. King could spare but little time to land, and, with few exceptions, merely traced the coast. The paucity of geological information is thus accounted for, and the few references are merely lithological. John Oxley, Surveyor-General, to whom we owe the earliest topographical map of New South Wales, took charge in 1817 of an expedition to ascertain the character of the western interior, a practicable route across the Blue Mountains having been opened in 1815. He traced the Lachlan down to longitude 144°, and completed the discovery of the Blue Mountains, which constitute the prominent physiographic feature of New South Wales. In 1818 he traced the Macquarie River to its junction with the Darling. In the volume of his narrative are brief references to the occurrences of different rocks, amongst which the more noteworthy are coal at Port Macquarie Harbour, coal indications at the head of the Macleay River, and limestone at Limestone Creek on the Lachlan, and at Wellington Valley on the Macquarie, "which is the first that has hitherto been discovered in Australia." The geological specimens which were collected during the two expeditions were reported on by Dean Buckland as affording indications of primitive rocks (granite, mica, slate, clay-slate, and serpentine), trap, and limestone (resembling the transition limestone of England), as also those gathered by Robert Brown on the Hunter River, which are described as coal and shale with plant impressions, and the author states that there is analogy between the coal formation of the Hunter River and that of England, whilst certain fossiliferous rocks from Hobart are nearly, if not quite, identical with those of the mountain limestone of England and Ireland. This is the first application of palæontology to the stratigraphical chronology of the Australian rocks, and a successful one, as the positions assigned by Buckland to the two formations are substantially those accepted by the local geologists of to-day. Scott (Rev. Archdeacon) refers to the strata of the Newcastle coalfield as the "coal formation," and to the limestone as resembling in the character of its organic remains the "mountain limestone" of England, and thus independently arrived at the same conclusions as Buckland.

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[1] A part of the inaugural address delivered at Adelaide, on September 26, 1893, by Prof. Ralph Tate, the newly elected President of the Australian Association for the Advancement of Science.

Jesson, the naturalist to the French surveying ship, *La Coquille*, and author of the history of the voyage during the years 1822–25, describes the geological features about Port Jackson. His arrangement is a great advance on prior contributions, as it establishes a definite successional order of deposits, and for the first time, though foreshadowed by his countryman Bailly, the superposition of the Sydney sandstone on the coal measures, and of the coal measures on the granites, is recognised. Up to this date no described fossil had been referred to as occurring in Australian deposits, and it was not till 1828 that Alex. Brongniart described *Glossopteris browniana* and *Phyllotheca Australis* from the Newcastle coal measures.

Sturt, in 1829, on his passage down the Murray, arrived at Overland Corner, and noted the sudden change from cliffs of sand and clay to fossiliferous limestone, which continued uninterruptedly to Lake Alexandrina. Sturt referred examples of the fossil mollusca, echinoids, and polyzoa, to species of the Eocene of England, Paris, and Westphalia, and thus established by similarity of organic remains, an old tertiary formation in Australia.

Mitchell (Major, afterwards Sir Thomas), in 1832 penetrated north, and reached the River Darling. His western limit in 1835 was the junction of the rivers Bogan and Darling, and the southern, in 1836, was Portland Bay. The chief geological facts recorded by Mitchell are: (1) That the higher ground about the sources of the tributary of the Murrumbidgee is composed of granite, on the flanks of which rests a fossiliferous limestone "much resembling the carboniferous of Europe," and another limestone containing corals belonging to the genus Favosites, and crinoids; (2) in Victoria, north of the divided range, granites and syenites are signalled, and clay slate on the river Campaspe; (3) the lower part of the Glenelg River and the coast districts as far as Portland Bay are occupied with a fossiliferous tertiary formation, frequently interrupted by trap and vesicular lava; hills of lava often occur, and one at least, Mount Napier, is described as still exhibiting a perfect circular crater.

The palæontological collections, which were made during Mitchell's three expeditions, were deposited in the British Museum, and reported on by specialists. The results appended to Mitchell's work demonstrated the presence of representatives of the following life epochs: Carboniferous and Mesozoic. The collection included also a portion of the guard of a belemnite obtained near Mount Abundance. Its occurrence is noted on Mitchell's chart, though not referred to in the letter-press. This is the first secondary fossil recorded for Australia, though it was not till 1880 that it was brought to scientific notice.

Diprotodon Period.—The ossiferous caves of the Wellington Valley and at Buree were discovered by Mitchell in 1830, and an account of the survey of them was published in 1831. In 1835 more extended researches were undertaken, and the particulars respecting the animal remains then found were supplied by Owen (afterwards Sir Richard), who demonstrated that the existing marsupial fauna was preceded in the same area in later tertiary times by a similar one, differing specifically for the most part, and to some extent, generically; some of them presenting colossal forms in comparison with their largest modern representatives; such are Diprotodon and Nototherium. This early work of Owen's was only the commencement of those investigations which culminated in that monument of marvellous industry and talent, the "Fossil Mammals of Australia." Charles Darwin was naturalist to the surveying ship, the *Beagle*, on her second voyage, 1832–36. The *Beagle*, on her homeward passage, called at Sydney and King George's Sound, and the geological observations relating to those places are brief, and, to a large extent, had been anticipated by Mitchell in respect of the first, and by Peron as to the second, though in the latter connection Darwin corrected some of the erroneous observations recorded by Vancouver and Flinders. Lonsdale describes some Australian carboniferous polyzoa, and Sowerby some Spiriferidæ, and we have thus another instance of the early application of palæontology to the determination of the correlative age of stratified deposits.

Lieutenant Grey (now Sir George) was commissioned to explore the coastline between Prince Regent River and Swan River. In 1839 he was shipwrecked in Gantheaume Bay, and his party was forced to make an overland journey to Perth, in the course of which he discovered the Murchison and other rivers, and carboniferous rocks in the Victoria Range.

Commander Wickham was commissioned in 1837 to the *Beagle's* third voyage, but in consequence of his retirement in March, 1841, owing to ill-health, the command devolved on Captain Stokes, who is the author of the narrative of the six years' voyage. The objects of the survey did not permit of any connected observations of the geological structure of the islands or coast, and though the author disclaims any pretensions to be versed in geological science, yet some of his recorded observations have the merit of discoveries which have stood the test of critical investigation. The escarpment of the table-land of Arnheim Land is described as constituted of horizontally-bedded sandstone overlying slaty rock; a somewhat similar arrangement is noticed at Talc Head and Fort Hill, Port Darwin; the covering, fine-grained sandstone, the stratigraphical position of which was first observed by Stokes, has lately acquired considerable importance by the discovery of Radiolarians within its mass.

Strzelecki (Count).—To this highly accomplished man of science we are greatly indebted for arduous and gratuitous researches and labours in the field of Australian geology, the outcome of five years' travel, commencing from his traverse of Gippsland in 1840, and embracing the survey of 7,000 miles. The rocks of New South Wales he arranges in an ascending successional series, and in this first attempt to construct a table of the stratified deposits of New South Wales he laid the foundation of stratigraphical geology in Australia. Strzelecki's volume is accompanied by a map in which the areas occupied by each epoch are indicated by colours, and is the first attempt at geological mapping in Australia.

Leichardt (Dr. Ludwig).—In 1844 this lamented traveller started on his adventurous journey from Moreton Bay to Port Essington, a distance of 3000 miles. The narrative of Dr. Leichardt contains as much botany as geology. The accompanying maps and illustrations supply important information respecting the physiographic and geologic features. Necessity compelled him to abandon one portion after another of his collections, so that the opportunity of determining the age of the various deposits encountered, from the nature of their fossil contents, was lost. This is much to be regretted, because for long years this line of country was geologically known only through Leichardt's memoranda, which still contain for some portions the only information extant.

Dana (Prof. James D.) was naturalist to the United States exploring expedition during the years 1838–42, under the command of Charles Wilkes. Sydney was visited in 1839–40, but as the geology of the expedition was not published till 1849, Dana's observations were to some extent anticipated. Nevertheless, the credit must remain to Dana of having laid the foundation of the classification of the great carboniferous development in New South Wales, both in respect of its palæontology and stratigraphy.

Sturt (Captain Charles), in 1844, under the authority of the Imperial Government, pushed into the central parts of Australia. From the River Darling, at what is now Menindie, he reached the Barrier and Grey Ranges, and became entangled in the delta-like ramifications of the River Cooper; thence he penetrated in a north-west direction into the sand-dune country to the north-east of Lake Eyre, and thus missed the object of his ardent search. Sturt describes the general structure of the Barrier Range as of slates, gneiss, and other metamorphic rocks, and notes the prevalence of iron ores. In one case he describes what is evidently the ironstone outcrop of a massive mineral lode, and though I cannot identify the locality, yet it is not at all improbable that one of the silver lodes of the Barrier (if not Broken Hill itself) is here referred to; in the same connection that prominent landmark, Piesse's Knob, is indicated. The most noteworthy observations recorded by Sturt are those relating to the physical character of the interior of Australia, which will be considered hereafter. A tribute is due to Sturt's scientific merit and sagacity, and I would add my mite to the general testimony of admiration for that learned traveller; he stands pre-eminent among land explorers for the accuracy of his observations—evincing the most patient and thoughtful investigation—for the great power of generalisation which throws a charm over all his narratives, and for his highly philosophical deductions. Sturt never received that honour in his lifetime which was his due; and much of his geological work and speculations have either been overlooked or ignored, because it was thought, by reason that geology then was not in a very advanced state, he was not a very experienced geologist. In his work, "A Sketch of the Physical Structure of Australia" (1850), the author gives a connected outline of the geology of Australia, so far as it was known to him. The great merit of this attempt to exhibit approximately the principal features of this continent is that of piecing together the isolated observations of previous authors into a connected outline, which, because of his personal knowledge of considerable portions of the coastline of Australia, he was, of all others, the best able to do successfully. The result is a general but distinct notion of the geological structure of Australia, which is further illustrated by a geologically-coloured map, the first on so broad a survey. The author added nothing to our previous knowledge, but systematised what was known, and the speculations and generalisations which he ventured have, for the most part, proved correct. Some of the most valuable contributions of later authors will be found to have been foreshadowed, or even clearly noted, by Jukes, whilst some actual discoveries were anticipated by him.

The last of the maritime surveys under Imperial direction which concerned Australia was that conducted by Captain Owen Stanley, of H.M.S. *Rattlesnake;* it is also noteworthy from the high scientific attainments of its officers. The commander, who was the only son of Dean Stanley, an eminent ornithologist, took a keen interest in natural history; he died soon after the final return of the ship to Sydney, from a severe illness, contracted during the last cruise, but after the successful accomplishment of the chief object of his mission. The assistant-surgeon was Thomas H. Huxley, a name familiar to all, who achieved fame at this early period of his career by the zoological researches made during the voyage.

A. C. Gregory.—The discouraging character of the interior of Australia, as made known by Sturt, and the utter disappearance of Leichardt's expedition of 1848, checked the progress of exploration for a few years; but in 1855 a successful effort was made to penetrate the interior from the north-west by the North Australian expedition, which was fitted out by the Imperial Government, and was the last of the series. The expedition was placed under the leadership of Mr. A. C. Gregory, who was accompanied by Dr. (now Baron Sir F. von) Mueller as botanist. The Victoria River was ascended to its source, and the country to the south of the Dividing Range was explored beyond the northern limits of the great interior desert. The physiographic features of the Lower Victoria had been made known by the descriptions of Stokes; the region about the Upper Victoria was found to consist chiefly of extensive valleys of good soil, well grassed, and of more arid sandstone table-land, varied with outcrops of basalt, constituting rich grassy downs. The table-land rises abruptly from the coastal tracts. By removal of the upper strata deep gorges 600 feet in height are formed, which open out into large valleys or plains. Mr. Gregory struck across from the Lower Victoria to the head of Roper River, and thence followed the base of the table-land from which he had descended, passing near the sources of the rivers discharging into the Gulf of Carpentaria. From the Albert River to Brisbane he followed Leichardt's route of 1844. This extraordinary achievement is second to none in point of interest of unknown country traversed, and of the scientific results gained, a vast void in the geological map was filled in. Since Gregory's expedition the interior of Australia has been traversed in various directions; and with such efforts are honourably associated the names of Stuart, Burke and Wills, Warburton, Giles, J. Forrest, &c., but the geological gain has been of a purely local importance. I may therefore be pardoned if I make exception by the mention of the expedition recently fitted out by Sir Thomas Elder. The object—to fill up the blank spaces in the topographical and geological maps of Australia—was ambitious, and the scientific equipment of the expedition gave hope that permanent results would be gained, but its premature disbandment has indefinitely protracted the realisation of this cherished consummation. So far as the area traversed is concerned, a very great deal was accomplished. It was a failure simply by reason of the limitation of the original scheme. In geology nothing new has been brought to light, though certainty has replaced previous guesswork or speculation. Nevertheless, such problems as the exact relation of the fossiliferous Silurian to those of older date, the stratigraphy and fossils of the marine Cretaceous, and its relation to the supra-cretaceous rocks, still await solution. The geologist to the expedition has done his work so conscientiously and thoroughly, that the poverty of his report is to be ascribed to nature's deficiency. In other departments of natural history our expectations have been satisfactorily realised. May we hope that the Australian Macænas of our time will crown his efforts to unfold some of the mysteries of our dry interior by directing a systematic exploration of some well-defined area, such as the oasis of the MacDonnell Range.

The year of 1851 marks an epoch in the history of Australia, because in that year the rich goldfield of Ophir was discovered. Gold was scientifically discovered by Strzelecki, in 1839, and by

Clarke in 1841, though its existence would appear to have been known as early as 1823. In 1844, without being aware of these discoveries, Sir Roderick Murchison pointed out the similarity of the rock structure of the eastern cordillera of Australia to that of the Ural Mountains, and predicted the occurrence of gold. Subsequent events afforded a proof that geology, like the more exact sciences, is capable of advancing philosophical inductions to very important results. But the precious metal was not commercially discovered, so to speak, till 1851, by Hargreaves, who had spent some of his earlier years as a stock-raiser in Eastern Australia; in 1849 he was gold mining in California, and his experiences there gained convinced him of the similarity in structure of the auriferous rocks of California and certain districts in New South Wales. He revisited New South Wales early in 1851, to put to the test his geological instinct and the accuracy of his observations; in this he succeeded, and ultimately, under Government direction, the gold-field of Ophir in the district of Bathurst was declared open. He was awarded £10,000 for his discovery, and in 1876 a pension was granted him. He died in 1891, at the age of 75 years. The practical discovery of gold proved a source of an enormous amount of wealth to New South Wales, and was soon followed in the same year by the discovery of much richer goldfields in Victoria, which had just then been separated into an independent colony, and thus added a powerful factor to the economic and scientific advancement of the continent. The consequent stimulus to a higher intellectual culture resulted in the foundation of the Universities of Sydney and Melbourne, and the establishment of systematically organised geological surveys. By the concurrence of the memorable events just alluded to, the history of geological progress enters a new period. Up to 1854 our exact knowledge of the sedimentary deposits, as derived from the organic remains, was confined to the Carboniferous, to a late Tertiary (represented by the Diprotodon period), and a more recent Æolian formation; no distinct identification to prove the existence of Upper Silurian, Devonian, or Eocene had been forthcoming, though it was implied, whilst the only evidence of a Mesozoic epoch was a single imperfect example of a Belemnite. Restricted means of communication in a vast extent of country was the main cause which retarded advancement in geological investigation; with increasing population this barrier is gradually being removed. Expansion of our pastoral occupation, and the opening out of new trade routes bring new fields within the horizon of geological vision. It is, therefore, not a matter for surprise that in the next decade great and rapid advances were made in establishing a comparison on palæontological grounds with corresponding geological systems of Europe. The history of geological progress in the second half-century is mainly that of the geological surveys, and the chronological treatment of my subject must be abandoned at this stage.

It is a general impression that Australia is a very old continent; undoubtedly it is, because it presents an equal range of the geological record as other continental masses. But this impression is based on illogical deduction, derived solely from the fact that certain characteristic types of the Jurassic fauna of the northern hemisphere still linger in the Australian area, such as Trigonia, Ceratodus, and Marsupials among animals, Cycads and certain Conifers among plants. But the physiographic aspects of Australia have not always been absolutely continental. Since Upper Devonian times there have always been land-surfaces, at any rate in Eastern Australia, where partial interruption to an absolute continuity (and the area locally affected is not relatively great) was frequent during the deposition of the Carboniferous series, which is, however, in a large measure littoral. It may safely be asserted that Australia, certainly so far back as the deposition of the extensive marine Cretaceous occupying the low level tracts of the interior, preserved the aspect of a vast archipelago. At the close of that epoch the various insular masses became welded together, so that the antiquity of Australia as a whole is only post-Cretaceous. In early Eocene or late Cretaceous times, the flora was of a cosmopolitan type, consisting of an admixture of generic forms, some of which are now proper to the temperate and sub-temperate parts of the northern hemisphere, such as oaks, birch, alder, &c., and others exclusively Australian, such as eucalypti, banksias, Araucarias, &c. The differentiation of the Australian flora has therefore been brought about during the post-Eocene times. The antiquity of Australia, as inferred from its almost exclusive marsupial types, is erroneous, because there is every reason to doubt the correctness of the statement thereby implied that marsupials originated in Australia. Despite the recurrences of land surfaces from late Palæozoic times to the present day—and it is not improbable that some of them may have been permanent throughout, or for a greater part of that long interval—yet no marsupials as old as those of Europe and North America have yet been found; neither its coaly strata nor its ancient lake basins have yielded any of the higher types of fluviatile or terrestrial vertebrates. Indeed, the only instance of a fossil representative of the Marsupialia older than Pliocene in the Australian area is that of a diprotodontoid in the Eocene beds at Table Cape, Tasmania; whereas we must look for a polyprotodontoid as the early ancestor of the class. Recent researches point to South America as the area from which the Australian marsupial fauna has probably been derived, which possesses in the Eocene marsupial fauna close alliances with certain existing polyprotodontoid types in Australia.

A DYNAMICAL THEORY OF THE ELECTRIC AND LUMINIFEROUS MEDIUM.[1]

II.

THE next stage in this mode of elucidation of electrical phenomena is to suppose, once the current is started in our non-dissipative circuit, that both the condensers are instantaneously removed, and replaced by continuity of the wire. We are now left with a current circulating round a complete perfectly conducting channel, which in the absence of viscous forces will flow round permanently. The expression for the kinetic energy in the field is easily transformed from a volume integral of the magnetic force, which is represented by the velocity of the medium $\frac{d}{dt}(\xi, \eta, \zeta)$, to an integral involving the current $\frac{d}{dt}(f, g, h)$, which is in the present case a line integral round the electric circuit. The result is Franz Neumann's celebrated formula for the electromagnetic energy of a linear electric current,

$$T = \tfrac{1}{2}\iota^2 \int\!\!\int r^{-1} \cos \epsilon \, ds \, ds \, ;$$

or we may take the case of several linear circuits in the field, and obtain the formula

$$T = \tfrac{1}{2}\Sigma\iota^2 \int\!\!\int r^{\ 1} \cos \epsilon \, ds \, ds + \Sigma\iota_1\iota_2 \int\!\!\int r^{\ 1} \cos \epsilon \, ds_1 \, ds_2,$$

which is sufficiently general to cover the whole ground of electro-dynamics.

Our result is in fact that a linear current is a vortex ring in the fluid æther, that electric current is represented by vorticity in the medium, and magnetic force by the velocity of the medium. The current being carried by a perfect conductor, the corresponding vortex is (as yet) without a core, *i.e.* it circulates round a vacuous space. The strength of a vortex ring is, however, permanently constant; therefore, owing to the mechanical connections and continuity of the medium, a current flowing round a complete perfectly conducting circuit would be unaffected in value by electric forces induced in the circuit, and would remain constant throughout all time. Ordinary electric currents must therefore be held to flow in incomplete conducting circuits, and to be completed either by convection across an electrolyte, or by electric displacement or discharge across the intervals between the molecules, after the manner of the illustration given above.

Now we are here driven upon Ampère's theory of magnetism. Each vortex-atom in the medium is a permanent non-dissipative electric current of this kind, and we are in a position to appreciate the importance which Faraday attached to his discovery that all matter is magnetic. Indeed, on consideration, no other view than this seems tenable; for we can hardly suppose that so prominent a quality of iron as its magnetism completely disappears above the temperature of recalescence, to reappear again immediately the iron comes below that temperature; much the more reasonable view is that the molecular rearrangement that takes place at that temperature simply masks the permanent magnetic quality. In all substances other than the

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[1] A paper read before the Royal Society on December 7, 1893, by Dr. Joseph Larmor, F.R.S., Fellow of St. John's College, Cambridge. (Continued from p. 262)